Foundation – Module 1

ELO-020 Identify the benefits of consuming cloud services;

ELO-030 Identify the benefits or characteristics of a service that distinguishes it as a cloud service;

ELO-040 Identify three advancements in technology that enabled the rise of cloud computing (marketing concept).

Module – 1: Foundation

Topics

- Module Introduction
- History
- Motivation
- Module Review
- Module Summary Questions

You should be able to:

- Identify three advancements in technology that enabled the rise of cloud computing [History]
- Identify the benefits of consuming cloud services. [Motivation]
- Identify the characteristics of a service that distinguishes it as a cloud service.
- Match terms from the section to appropriate definitions.

Introduction

Topic

Introduction

You should be able to:

Questions

Content

- **Introduction**
- Purpose: This learning module will introduce you to cloud computing and the DoD's approach to adopting "the cloud."
- The CLM will consist of 7 "bite sized" modules that will cover technology, cybersecurity, and acquisition issues related to cloud.
- The goal is to provide practitioners in a variety of areas gain a basic awareness and understanding of cloud and how to approach the topic within the DoD.
- This CLM is going to open with a fictional, though realistic, situation that will set the context and focus the material you are about to cover in a practical manner. Think of yourself as a member of a team that is new to cloud but tasked with investigating cloud based solutions and making a recommendation on which one to choose.

Introduction – Fictional Scenario

Topic

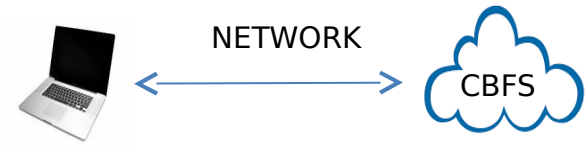
Acquisition Scenario

You should be able to:

Questions

Content

- **Background**: As a result of an intensive lobbying effort by a commercial cloud storage company we have been asked to explore what it would take to migrate to a cloud-based file sharing solution and recommend a way forward for the DoD.
- **Use Case**: From my DoD laptop I want to 'connect' to the cloud and use it like a local disk drive to archive my emails and store and share my unclassified documents with other users connected to the DoD's Information Network (DODIN).
- The assignment is ambitious and requires that we follow current DoD Cloud Policy and use of the "5 step process" that the policy describes.
- However, before diving into those policies and processes we will first provide: a brief history of and advancements in information technology; a look into commercial industry's success in taking advantage of the advances; some basic vocabulary; what a cloud "looks like;" and the benefits and risks to the DoD when using cloud technologies to store and process DoD data.



History, page 1

Topic

History

You should be able to:

1. Identify three advancements in technology that enabled the rise of cloud computing [History]

Questions

1. What processor technology became the industry standard? Answer: X86

Content

- **History**
- Identify three advancements in technology that enabled the rise of cloud computing [History]
- Commodity hardware and widely adopted standards.
- Pervasive high seed networks to move the “bits.”
- Virtualization: means to divide a physical resource into multiple virtual instances of a resource; e.g. compute, storage, network. Virtualization is the primary enabling technology behind cloud computing.
- Open application programming interfaces (APIs) to integrate, manage, and control the virtual devices.
- Tenets of Service-oriented Architecture (SOA) e.g. APPLICATION = set of integrated network services.
- Essential characteristics that all cloud services exhibit: on-demand self-service, broad network access, resource pooling, rapid elasticity, and measured service.

History of Cloud Computing

Topic

History of Cloud Computing - 1

You should be able to:

Questions

Content

- **History of Cloud Computing - 1**
- Although cloud computing is popularly viewed as a recent trend in IT, the concept originated in the 1950s with mainframe computing, where multiple users accessed the central mainframe through dumb terminals that provided shared access to a single source of storage and processing power. (Thoughts on Cloud, 2015)
- The idea was further matured in the 1960s by like J.C.R. Licklider who envisioned a global computer network that allowed everyone to access programs and data anywhere; hardware virtualization being pioneered by companies like General Electric, Bell Labs, and International Business Machines (IBM); and John McCarthy's idea of computation as a public utility in 1961. (Mohamed, 2009)
- However, as processing moved from central mainframes to personal computers and dedicated servers in the 1980s and 1990s, the desire for centralized computer services waned.
- It was not until the last ten years that enhanced services and increased bandwidth allowed cloud computing to begin to transform commercial IT. (TechTarget, n.d.) (Mohamed, 2009)

History of Cloud Computing

Topic

History of Cloud Computing - 2

You should be able to:

Questions

Content

- Companies started to become attracted to benefits such as reduced capital and IT staffing costs, and when they switched to cloud services.
- The present availability of high-capacity networks and low-cost computers, together with the adoptions of virtualization and service-oriented architecture, have led to present day cloud computing. (TechTarget, n.d.)
- Cloud services are also able to provide efficient storage and processing of the ever-increasing amount of data that industry collects. (Mohamed, 2009)
- As a result, industry has consistently increased its spending on cloud computing services to the extent that Forrester Research expects global public cloud purchases to rise from $72 billion in 2014 to $191 billion in 2020. (Bartles, Rymer,)
- Major industry players such as Amazon, Google, Microsoft, and Sales Force, as well as small business and IT equipment manufacturers and academia, have driven the evolution and led the major developments in modern cloud computing. It is important to note that many of the major developments have occurred only in within the last few years.

History – Context of Cloud in the DoD

Topic

Historical context of Cloud Computing in the DoD

You should be able to:

Questions

Content

- DoD has historically relied on on-premises DoD data centers to host applications and provide IT infrastructure.
- These data centers are widely dispersed across military Services, installations and vary in management, operation, capability, and cybersecurity.
- Traditional data centers suffer from slow upgrade periods and frequently low utilization (averaging 30% utilization). (DOD CIO, 2012, p. 4)
- Cloud computing technologies offers a way for the DoD to lower costs, improve performance, increase utilization and security, and take advantage of innovation taking place in the commercial industry.

Benefits of Cloud Computing – 1

Topic

Benefits of Cloud Computing - 1

You should be able to:

Questions

Content

- In traditional computing models, an organization can grow its IT infrastructure by purchasing the necessary equipment or devices and integrating the new components into legacy systems.
- This is a costly and time-consuming activity, especially for smaller organizations. Even after IT upgrades, the problems of underutilization of computing resources and managing complex IT networks persist.
- Cloud computing offers a potential solution with on-demand elasticity in IT services for any size enterprise and allows organizations to accommodate spikes in demand for their content by gaining the advantages of the economies of scale associated with pooling IT resources.
- Cloud computing also allows organizations to focus on their core missions and minimizes the distractions of building and managing IT solutions. For example, IT departments can move to a cloud environment and "get out of the business of racking and stacking servers." Transitioning to a cloud infrastructure could potentially result in higher productivity by allowing the reassignment of system administrators to other roles.

Benefits of Cloud Computing – 2

Topic

Benefits of Cloud Computing - 2

You should be able to:

Questions

Content

- Finally, simplified internal operations and business agility are additional advantages to using cloud computing, although the customer still needs to maintain contract oversight to ensure compliance with their requirements.
- Cloud computing allows for rapid improvements to infrastructure, services and technology, that is not possible with traditional IT acquisitions.
- When new processing or storage capacity is added, those speed improvements can be seen across the entire cloud infrastructure.
- When commercial cloud providers add new services, those services can immediately be utilized by all of that provider's customers.
- The rapid evolution of technology and increased adoption of cloud platforms also leads to pricing that decreases over time. For example, between 2008 and 2014, Amazon announced 42 price reductions for its Amazon Web Services (AWS) offering.

Advancements in Technology – Commodity Hardware and Software

Topic

Commodity Hardware and Software

You should be able to:

Questions

1. What processor technology became the industry standard? Answer: X86

Content

- The pre-dominate computer architecture today is Intel X86 – the vast majority of all enterprise applications run on this hardware.
- The pre-dominate operating system in use today is Microsoft based and to a lesser degree Linux.
- There are edge cases where these generalizations do not apply; however, these two de-facto standards have helped simplify the environment and improve developer efficiencies.
- In the case of X86 it has also led to an explosion in hardware virtualization.

Advancements in Technology – Virtualization

Topic

Virtualization

You should be able to:

Questions

Content

- We understand the idea of physical – something solid that we can touch, feel, and handle. A laptop computer, RAM, and hard disk drive are examples of physical computing hardware.
- We understand the idea of virtual – something we can perceive and manipulate in a way that represents or mimics something physical. For example, virtual reality as found in many computer games, a movie, or virtual memory for a computer. Virtual memory is software in the operating system that allows an computer to 'think' it has a greater amount RAM than is physically installed in the machine.
- In a similar way a layer of software known as a hypervisor allows multiple operating systems to share the physical elements of a single physical computer (e.g. CPU, RAM, Disk, Network Interfaces, etc.). The hypervisor manages the physical resources in such a way as to make each OS "think" it is running on its own hardware.
- Virtualization is important because most physical servers are estimated to be idle 90% of the time. So, if an application currently runs on 4 physical servers it could, in theory, run on 1 physical server in 4 virtual machines.
- This leads contributes reducing critical resource and cost factors such as power, space, and cooling in data centers.

Advancements in Technology – APIs

Topic

Application Programming Interfaces

You should be able to:

Questions

1. Note to developer – see articles such as

   http://devops.com/2014/05/05/meet-infrastructure-code/

Content

- In computer programming, an application programming interface (API) is a set of routines, protocols, and tools for building software applications. An API expresses a software component in terms of its operations, inputs, outputs, and underlying types. An API defines functionalities that are independent of their respective implementations, which allows definitions and implementations to vary without compromising the interface. A good API makes it easier to develop a program by providing all the building blocks. A programmer then puts the blocks together. [WP]
- Web APIs are the defined interfaces through which interactions happen between an enterprise and applications that use its assets. An API approach is an architectural approach that revolves around providing programmable interfaces to a set of services to different applications serving different types of consumers. When used in the context of web development, an API is typically defined as a set of Hypertext Transfer Protocol (HTTP) request messages, along with a definition of the structure of response messages, which is usually in an Extensible Markup Language (XML) or JavaScript Object Notation (JSON) format.

Advancements in Technology – APIs

Topic

Application Programming Interfaces

You should be able to:

Questions

1. Note to developer – see articles such as
   http://devops.com/2014/05/05/meet-infrastructure-code/

Content

- While "web API" historically has been virtually synonymous for web service, the recent trend (so-called Web 2.0) has been moving away from Simple Object Access Protocol (SOAP) based web services and service-oriented architecture (SOA) towards more direct representational state transfer (REST) style web resources and resource-oriented architecture (ROA). Part of this trend is related to the Semantic Web movement toward Resource Description Framework (RDF), a concept to promote web-based ontology engineering technologies. Web APIs allow the combination of multiple APIs into new applications known as mashups.

Advancements in Technology – SOA

Topic

Service-Oriented Architecture

You should be able to:

Questions

Content

- SOA is another important characteristic
  - "A service-oriented architecture (SOA) is an architectural pattern in computer software design in which application components provide services to other components via a communications protocol, typically over a network. The principles of service-orientation are independent of any vendor, product or technology" [WP]
- As we will discuss in subsequent modules, "Cloud Service Offerings" (CSOs) all offer "service interfaces' (like an API) which allow "Cloud Service Providers" (CSPs) to develop and deliver their CSO by assembling services from other CSPs.
- For example, providing virtual machines, storage, and networking is one of the most common cloud service offerings available today (this is called Infrastructure as a Service). Coincidentally, every software application requires these resources and until the advent of cloud computing, the developer of the application had to acquire, set-up, and operate these components.
- In the era of cloud, an application developer (let's call them Spend Force) can now purchase the infrastructure from a CSP (let's call them Rain Forest) and develop and deliver their distinct 'cloud application' using that Rain Forest's infrastructure service offering.
- In this case:
  - Spend Force can concentrate on the development of the application;
  - the user of Spend Force does not know that Rain Forest is being used.

Advancements in technology – Example

Topic

Advancements in technology – Example

You should be able to:

Questions

Content

There are other important ideas to consider (though not explicitly mentioned) when looking at Rain Forest and Spend Force. For example,

- Rain Forest provides an on-line ordering capability as well an GUI that allows the Spend Force to administer their resources directly. (this is knows as on-demand self-service);
- The Rain Forest and Spend Force are service offerings are available over the internet. (this is known broad-network access);
- As a virtual infrastructure provider, Rain Forest uses software that manages all the physical resources and optimizes the way those resources are used. (this is known as resource pooling);
- Since Rain Forest exposes an API to the way the virtual resources are managed, Spend Force's application software can programmatically add or release resources as load on the application increases or decreases (this is known as rapid elasticity);
- Rain Forest only charges for the amount of time and the size of the resources used by Spend Force. (this is known as measured service)/

Concerns – Data Security

Topic

Data Security

You should be able to:

Questions

Content

- Some of the primary considerations of a government organization evaluating the use of cloud computing are data security, latency, and unanticipated costs.
- Security and privacy of the data in the cloud is a critical issue for government consumers. Cloud typically relies upon a shared environment, where multiple cloud tenants are leveraging the same infrastructure.
- Software controls and automated processes are able to separate tenants be defining "**virtual data centers**" that wall-off data and applications among different tenants; however, there are concerns that data of one tenant could be accessed across these virtual boundaries by another (perhaps malicious) tenant.
- Comingling of government and commercial data on the same cloud platform may be prohibited by regulatory requirements in certain circumstances. Keep in mind that the distributed nature of cloud means that data could be physically located at data centers in countries where U.S. laws do not apply.

Concerns – Data Security

Topic

Data Security – Hypothetical Scenario

You should be able to:

Questions

Content

- Recall that our Use Case for cloud: 'from my DoD laptop I want to 'connect' to the cloud and use it like a local disk drive to archive my emails and store and share my unclassified documents with other users connected to the DoD's Information Network (DODIN).' There are several issues to consider such as:
  - What happens if my emails were compromised;
  - Is the information in all my documents "Unclassified for Public Release;"
  - When sharing documents, can access (by other users) be controlled;
  - What happens if a spillage occurs (classified information is accidentally stored in the cloud);
  - Is there any special software that needs to be installed on my laptop to make this work
- Keep these kind of questions in mind as we progress through the course.

Concerns – Network Considerations

Topic

Network Considerations

You should be able to:

Questions

Content

- **Latency**
- Latency issues can be a concern because network traffic between users and remote cloud data centers can be slower than connections to local data centers.
- **Bandwidth**
- Cloud providers may have sufficient bandwidth to serve all of their customers, but bandwidth bottlenecks can still occur on the customer networks if those networks are not configured to support a more distributed architecture.
- Organizations seeking to utilize a cloud environment must ensure that their own network capacity is robust enough to handle the traffic load, especially for cloud services other than simple web applications (Bright, 2013)
- As more applications are moved to the cloud and bandwidth demands increase, cloud customers must continue to upgrade and optimize their networks, often at increased cost.
- **Cybersecurity**
- The DODIN is considered critical infrastructure and vital to our ability to carry out the DoD mission (to protect and defend the United States). You may not be aware of it, but all network traffic between the DODIN and the internet is monitored and is one aspect of the computer network defense (CND).

Concerns – Network Considerations

Topic

Network Considerations – Hypothetical Scenario

You should be able to:

Questions

Content

- The DoD has potentially millions of users for cloud based file storage. Questions that may come to mine are:
  - Is the provider mature enough (business, infrastructure, cybersecurity, etc.) to meet the requirements of the DoD;
  - Would networks latency be a factor;
  - How would the additional network traffic impact other enough DoD systems/missions;
  - Is the network traffic encrypted by the service provider;
  - Who is responsible for monitoring the network

Motivation – Unanticipated Costs

Topic

Underestimating Costs

You should be able to:

Questions

Content

- **Underestimating Costs**
- Organizations transitioning to cloud computing frequently underestimate the cost or difficulty of integrating cloud with legacy systems. This is largely because legacy applications were not designed, developed, or tested to work in a large
- When legacy systems are ported into a cloud environment, they will generally not be able to take advantage of the desirable features of a modern cloud without significant software development or retrofitting.
- Organizations with virtualized applications – applications that are encapsulated away from the underlying operating system – may more easily migrate to a cloud environment, but some applications or services may never be able to migrate.

Module 1 - Review

Topic

Summary

Content

You should be able to:

Questions

Module 1 – Summary Questions

Topic

Summary

Content

You should be able to:

Questions

Motivation – AWS Annual Report (provided as reference for the developer)

- IT departments are recognizing that when they adopt AWS, they get more done.
- They spend less time on low value-add activities like managing datacenters, networking, operating system patches, capacity planning, database scaling
- Just as important, they get access to powerful APIs and tools that dramatically simplify building scalable, secure, robust, high-performance systems.
- And those APIs and tools are continuously and seamlessly upgraded behind the scenes, without customer effort
- AWS is far less capital intensive than the mode it's replacing – do-it-yourself datacenters – which have low utilization rates, almost always below 20%.
- Pooling of workloads across customers gives AWS much higher utilization rates, and correspondingly higher capital efficiency.
- (AWS 2014 Annual Report)